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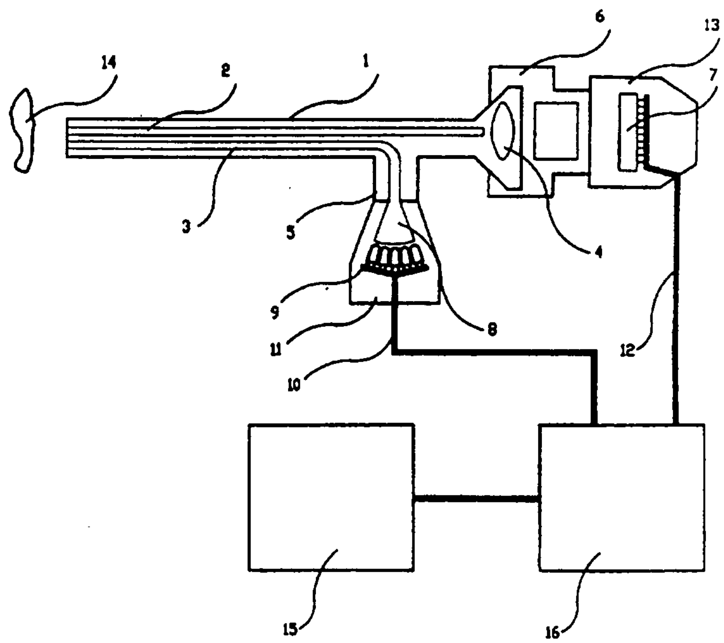
(54) Title: RANDOM ACCESS MULTISPECTRAL ILLUMINATION DEVICE FOR AN IMAGING SYSTEM

(57) Abstract

A real-time switchable random access color or color combination LED or laser diode illumination multispectral video imaging system comprising (switchable illumination means) a black and white photo-imaging array sensor, means for acquiring an image of an object, signal processing means for creating a color or false color video image of the object, control means for control of the spectral images combination ways, intensity, image overlay and other image processing means and a method for creating a real-time random access video image, where the object is illuminated by a desired number of LEDs whose output is combined to give a uniform, spectrally colored beam, and means for processing the obtained image. Preferably a color image is produced by electronically memorizing and combining three sequential images, each of them illuminated with one of the corresponding red, green and blue LED lights. One or more LED's are used, the light output being combined into a uniformly spectrally colored beam for object illumination. The system comprises also means for excitation light source for induced fluorescence purposes, and ability to detect and present chemiluminescence or phosphorescence or any other light emission induced effect in the observed object.



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DESCRIPTION

Random access multispectral illumination device for an imaging system.

Field of the invention.

The inventions relate to a real time switchable random access spectra, multispectral high resolution video imaging system coupled with random access switchable LED illumination means for close up direct or through endoscope inspection applications in Medicine, Industry and Research.

The new systems enables the user to create in real time a multispectral false color or true color image of an object, or to examine the object in any desired spectral band, in random order, from a pre-determined number of spectral bands, or to capture the induced luminescence from the object (fluorescence, chemiluminescence), all without interrupting the real time imaging process.

The new system presents a flexible color and multispectral high resolution imaging means for close-up applications and provide spectral selection of the imaging wavelength band in real time and at desired order.

In comparison to direct or through endoscope existing close-up video imaging and illumination systems, the system of the present invention is very economic in power consumption, can be battery operated and is comparatively inexpensive.

Background of the invention and State of Prior Art

Video imaging for close up inspection is a well known and widely accepted technique in the fields of medicine, research and industrial inspection. The most common demand is for color imaging and for some special research applications one can find also a few multispectral systems.

All those systems for color imaging require white light sources of high color temperature such as Halogen, Xenon and Metal Halide lamps.

There are many tasks of close-up inspection by video imaging in Medicine and Industry that are performed with the help of a rigid or flexible (fiber-optic) endoscope.

Color or Multispectral imaging through a flexible or rigid endoscope requires even more powerful light sources due to the high loss in the illumination fiber optic path. Due to the high color temperature and high intensity needs, all those light sources require special power supply electronics and cooling means, and are very power consuming 150W to 600W.

All those light sources are big, heavy and cannot be battery operated.

The life time (spectral characteristics and intensity) of all lamps in these light sources is very limited: ~50 hours for Halogen, ~250 hours for Metal Halide and ~300 to ~500 hours for Xenon, and this drawback imposes the use of a twin lamp light source for important tasks as medical operation, a feature that further increases the size and cost of the light source.

Fiber optic light guides for such systems are quite fragile and their high price makes maintenance expensive.

Metal Halide and Xenon lamps are strong UV emitters and therefore Ozone generators and their bulbs are pressurized, all those adding high safety requirements and additional cost to the product.

Regarding the CCD or CCD like imaging sensor of those systems there are two methods to produce a color image:

One method is to put a mosaic filter on the CCD active area, whicn divides the CCD pixels to different color sensitivity. This color mask decreases the resolution by producing images using only 1/3 of CCD cells in each color. The filter limits the CCD sensitivity because of its low transmission.

The second method is to use three CCD's. This kind of system gets a better resolution, but the sensitivity remains low because of the use of dichroic mirrors or color filters and prisms.

Such devices are large and expensive because of the use of three CCD's, and the need of special technology for accurate coupling of the CCDs to the prism high quality surface.

There exist a few multispectral systems that use high power white light sources like Xenon Lamps and a series of discrete narrow band filters which are mechanically interchanged in order to choose the spectral band of interest. Such systems are awkward and expensive and one cannot choose the desired spectral band at will in real time.

Summary of the Invention

The present inventions relates to a real-time switchable random access color or multi-color, multispectral video imaging system for close-up direct or through endoscope inspection based on a random access switchable multiwavelength LED illumination subsystem, and optionally Laser Diode excitation means.

More particularly, the invention relates to a real-time switchable random access color or color combination LED-or laser diode illumination multispectral video imaging system comprising a black and white CCD or CCD like imaging array sensor, an optical system for acquiring an image of an object, one or more single or

multiwavlength LED's whose light output is combined inco a uniformly spectrally colored beam for object illumination, electronic switching means for activating any of the LED's, as required, signal processing electronics for creating a black and white or false color or color video image of the object, control electronics for automatic and manual control of the spectral images order of appearance, intensity, image overlay and other image processing functions.

Advantageously the LED illumination comprises one or more single or multiwavelength LED's whole light output is combined by a LED's light beam combiner which is of a fiber optic multi-input with randomized fiber output type or of a dichroic mirror type or of a holographic diffuser type into a uniformly spectrally colored beam for object illumination. According to one embodiment, the imaging means comprises an imaging array sensor with peripheral components generating a non-standard video signal to be further processed by the electronic unit, where the imaging system comprises all the video signal processing electronics, or a dedicated single chip monolithic video camera. Preferably, a color image is produced by electronically memorizing and combining three sequential images, each of them illuminated with one of the corresponding Red, Green and Blue LED lights, where a false color multispectral image is produced by electronically memorizing three or more sequential images each of them illuminated with a specific LED wavelength and by electronically combining three of those images to be displayed on a color RGB monitor as a false color multispectral image. The imaged object response in a specific wavelength band can be enhanced by increasing the illumination intensity of the LED that delivers this specific wavelength. Advantageously there are provided means for shutting down all LEDs for a frame period or any other chosen period of time in order to facilitate the imaging sensor to record chemilluminescence or radio luminescence or phosphorescence or other light emitting induced effect in the object observed, where a switchable IR laser diode or a switchable UV excitation light source is coupled to the illumination light beam combiner for fluorescence diagnostic purposes. The electronic control unit comprises electronics required to create a

color or false color multispectral video imaging signal by analog and digital signal processing of the signals from the imaging unit and by synchronized switching and intensity control of the LED illumination light sources from the illumination unit.
There is provided a method for creating a real-time random access spectra multi-spectral video image, which comprises illuminating at will the object by a desired number of LEDs of an illumination system containing one or more simple or multiwavelength LEDs whose light output can be combined to give a uniform spectrally colored beam, and processing the obtained image. A color image can be produced by electronically memorizing and combining three sequential image, each of them illuminated with one of the corresponding red, green and blue LED lights, or where a false color multispectral image is produced by electronically memorizing three or more sequential images, each of them illuminated with a specific LED wavelength and by electronically combining three of those images to be displayed on a color RGB monitor as a false color multispectral image.
All LEDs can be shut down for a frame period or any other chosen period of time in order to facilitate the imaging sensor to record a chemilluminescence or radio luminescence or phosphorescence or other light emitting induced effect in the object or site under observation, where a switchable IR laser diode or a switchable UV excitation light source is coupled to the illumination light beam combiner for fluorescence diagnostic purposes.

The new system enables the user to create in real-time a multispectral false color or true color image of an object, or to examine the object in any desired spectral band, in random order, from a predetermined number of spectral bands or to capture the induced luminescence from the object (fluorescence, Chemiluminescence) all without interrupting the real time imaging process.

The system comprises a black and white or color CCD or CCD-like sensor (CID, MOS, Photo Diode array), with or without on chip memory, an optical system for acquiring an image of an object, signal processing electronics for creating a Black

and White or false color or color video image of the object, control electronics for automatic and manual control of the spectral image order of appearance, intensity, image overlay and other image processing function.

The system comprises LED illumination means containing one or more single or multiwavelength LED's and a beam combiner in order to create a uniformly spectral colored beam for object illumination, and electronic switching means for activating the LED's synchronizing their time and duration of operation, intensity and order of activation.

The LED illumination subsystem can be coupled to the imaging sensor and imaging optics or separated from it providing an illumination beam that illuminates the full Fields of View of the imaging sensor coupled to the specific optics. The signal processing switching means can be coupled to the imaging sensor, optics and LED illumination subsystem or be separated from it as a remote head system configuration.

The imaging optics in the system can be an ordinary optical system of any kind or a special dedicated optical system, for example a flexible or rigid endoscope optical system.

The CCD image sensor in the novel system is a black and white CCD, and therefore can be of a full frame type, providing higher resolution and sensitivity in comparison with existing color CCD's in the market.

A further advantage of the present invention is its low power requirements due to the low power requirements of the LED illumination compared to the high temperature, white light sources required for color video imaging. This advantage can be critical for the ability to design a battery operated portable illuminating color or multispectral video imaging systems.

The invention is exemplified by way of illustration only, and the examples are not to be construed in a limiting manner.

Fig. 1 is a block diagram of the novel random access multispectral video and illumination system for close-up imaging through an endoscope 1.

The control unit 16 controls the illumination unit 11 through the illumination cable 10 and the imaging unit 13 through the imaging cable 12. The illumination from the LED's 9 is combined by the light combiner 8 and interfaced to the light input 5 of the endoscope. The light is guided through the illumination fiber optic channel 3 of the endoscope to illuminate the inspected object 14. The image from the illuminated inspected object 14 is guided through the image channel 2 of the endoscope 1, to the ocular lens 4. An opto-mechanical adapter 6 is attached to the ocular, projecting the image on the image sensor 7. The obtained image signals are being led from the image sensor 7 through the image cable 12 to the control unit 16, in which they are being processed in order to provide the image information to a monitor 15.

Description of an embodiment of the novel system

Fig. 2 is an embodiment of the block diagram described in Fig. 1. The mode of illumination is determined by the user and entered by the control panel 34 to the controller 25 (68HC11 or equivalent). The controller 25 synchronized with the timing generator 22 (Sony CXD1261 or equivalent) sends a synchronized operating command to the LEDs 38 through the LED's cable 37. The LEDs 38 are an array of 5 LEDs of different wavelengths and a diffuser (*see list of LEDs at the end of this paragraph). According to Fig. 1, after the object is illuminated, an image is projected on the CCD image sensor 36 (Sony ICX058 or equivalent). The image sensor 36 is driven by the video driver 21 (Sony CXD1250 or equivalent) which synchronized by the timing generator 22. The image signal from the image sensor 36 is fed into the video processor 23 (Sony CXA1310 or equivalent) which provides video-like signal

into the analog to digital converter 26 (BT218 or equivalent). The output of the D/A 26 is a digital signal of the image fed into a digital memory 27 (TMS4C1050 or equivalent) for storage. After the memory is full with image information acquired from several illumination periods, and in response to the command from the controller 25, the full frame image is delivered to the D/A 28 (BT121 or equivalent), that provides an analog signal of the combined image to the buffer 29 (MC14577 or equivalent). The analog signal from the buffer is fed into the video encoder 30 (MC1377) which encode the signal to form a composite 31 and/or Y/C 32 and/or RGB 33 video signal. All the components are fed with power from the power supply 24.

* **List of LEDs in the illumination unit 38**

model	manufacturer	wavelength	color	power
NLPB500	NICHIA	450nm	BLUE	1000mcd
LMR53WE	SUN	660nm	RED	2000mcd
LMR653WB	SUN	565nm	GREEN	300mcd
AN305	STANLEY	950nm	IR	25mW/sr
DN305	STANLEY	850nm	IR	80mW/sr
LSD-TCN-5	POC	light shaping diffuser		

This list is an example list, equivalents are accepted.

Claims :

1. A real-time switchable random access color or color combination LED-or laser diode illumination multispectral video imaging system comprising a black and white CCD or CCD like imaging array sensor, an optical system for acquiring an image of an object, one or more single or multiwavlength LED's whose light output is combined into a uniformly spectrally colored beam for object illumination, electronic switching means for activating any of the LED's, as required, signal processing electronics for creating a black and white or false color or color video image of the object, control electronics for automatic and manual control of the spectral images order of appearance, intensity, image overlay and other image processing functions.

2. An imaging system according to claim 1 where the LED illumination comprises one or more single or multiwavelength LED's whole light output is combined by a LED's light beam combiner which is of a fiber optic multi-input with randomized fiber output type or of a dichroic mirror type or of a holographic diffuser type or of a compound parabolic concentration type into uniformly spectrally colored beam for object illumination.

3. A system according to claim 1, where the imaging part comprises the imaging array sensor with peripheral components generating a video signal to be further processed by the electronic unit, where the imaging system comprises all the video signal processing electronics, or a dedicated single chip monolithic video camera.

4. A system according to claim 1, where a color image is produced by electronically memorizing and combining three sequential images, each of them illuminated with one of the corresponding Red, Green and Blue LED lights, where a false color multispectral image is produced by electronically memorizing

three or more sequential images each of them illuminated with a specific LED wavelength from U.V. to near I.R. with a controllable intensity, and by electronically combining three of those images to be displayed on a color RGB monitor as a false color multispectral image.

5. A system according to claim 1, comprising means for shutting down all LEDs for a frame period or any other chosen period of time in order to facilitate the imaging sensor to record chemilluminescence or radio luminescence or phosphorescence or other light emitting induced effect in the object or site under observation, where a switchable IR laser diode or a switchable UV excitation light source is coupled to the illumination light beam combiner for fluorescence diagnostic purposes.

6. A system according to claim 1, where the electronic control unit comprise all electronic required to create a color or false color multispectral video imaging signal by analog and digital signal processing of the signals from the imaging unit and by synchronized switching and intensity control of the LED illumination light sources from the illumination unit.

7. A method for creating a real-time random access spectra multi-spectral video image, which comprises illuminating at will the object by a desired number of LEDs of an illumination system containing one or more simple or multiwavelength LEDs whose light output can be combined to give a uniform spectrally colored beam, and processing the obtained image.

8. A method according to claim 1 , where a color image is produced by electronically memorizing and combining three sequential image, each of them illuminated with one of the corresponding red, green and blue LED lights, or

where a false color multispectral image is produced by electronically memorizing three or more sequential images, each of them illuminated with a specific LED wavelength and by electronically combining three of those images to be displayed on a color RGB monitor as a false color multispectral image.

9. A method according to claim 1 , in which all LEDs can be shut down for a frame period or any other chosen period of time in order to facilitate the imaging sensor to record a chemilluminescence or radio luminescence or phosphorescence or other light emitting induced effect in the object or site under observation, where a switchable IR laser diode or a switchable UV excitation light source is coupled to the illumination light beam combiner for fluorescence diagnostic purposes.

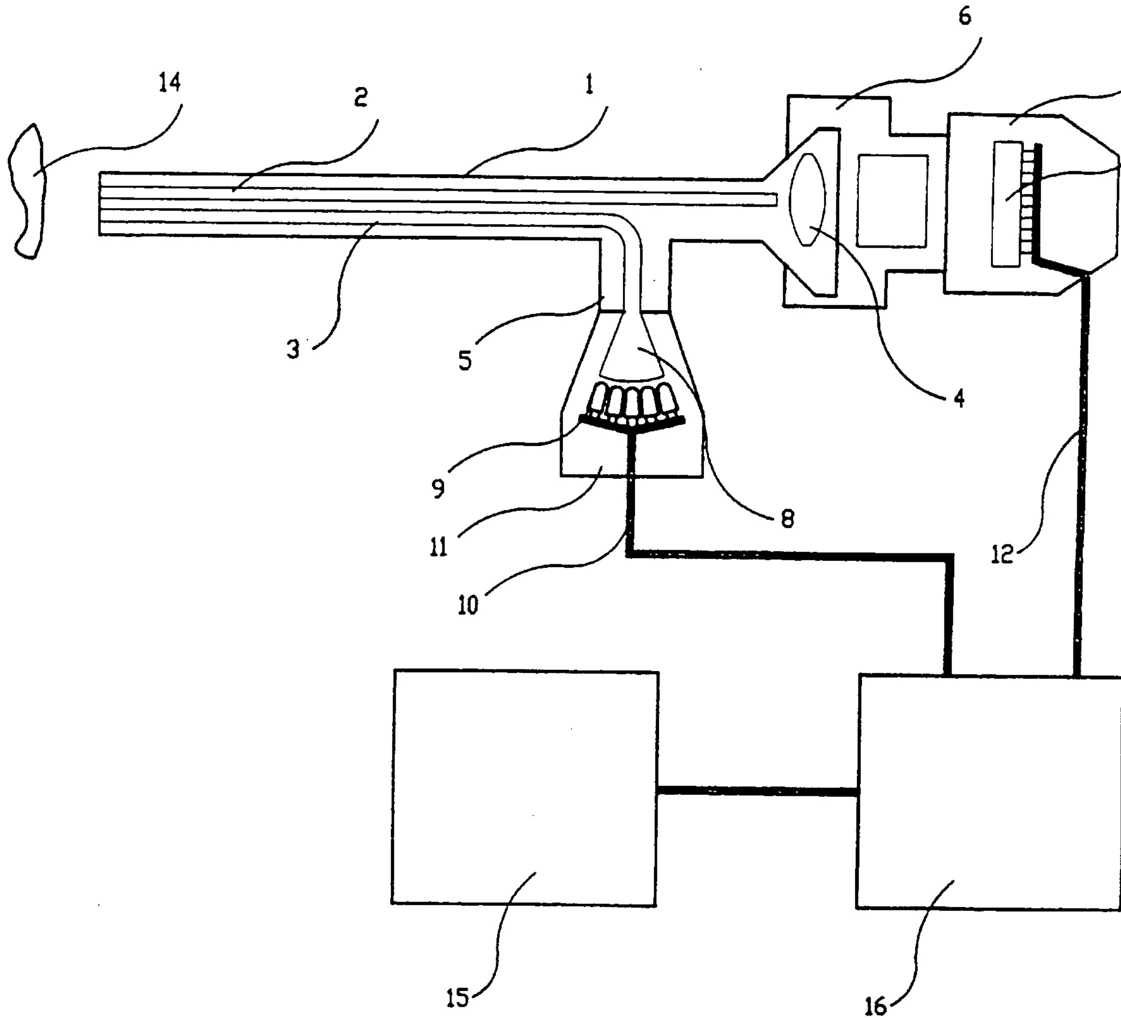

Fig.1

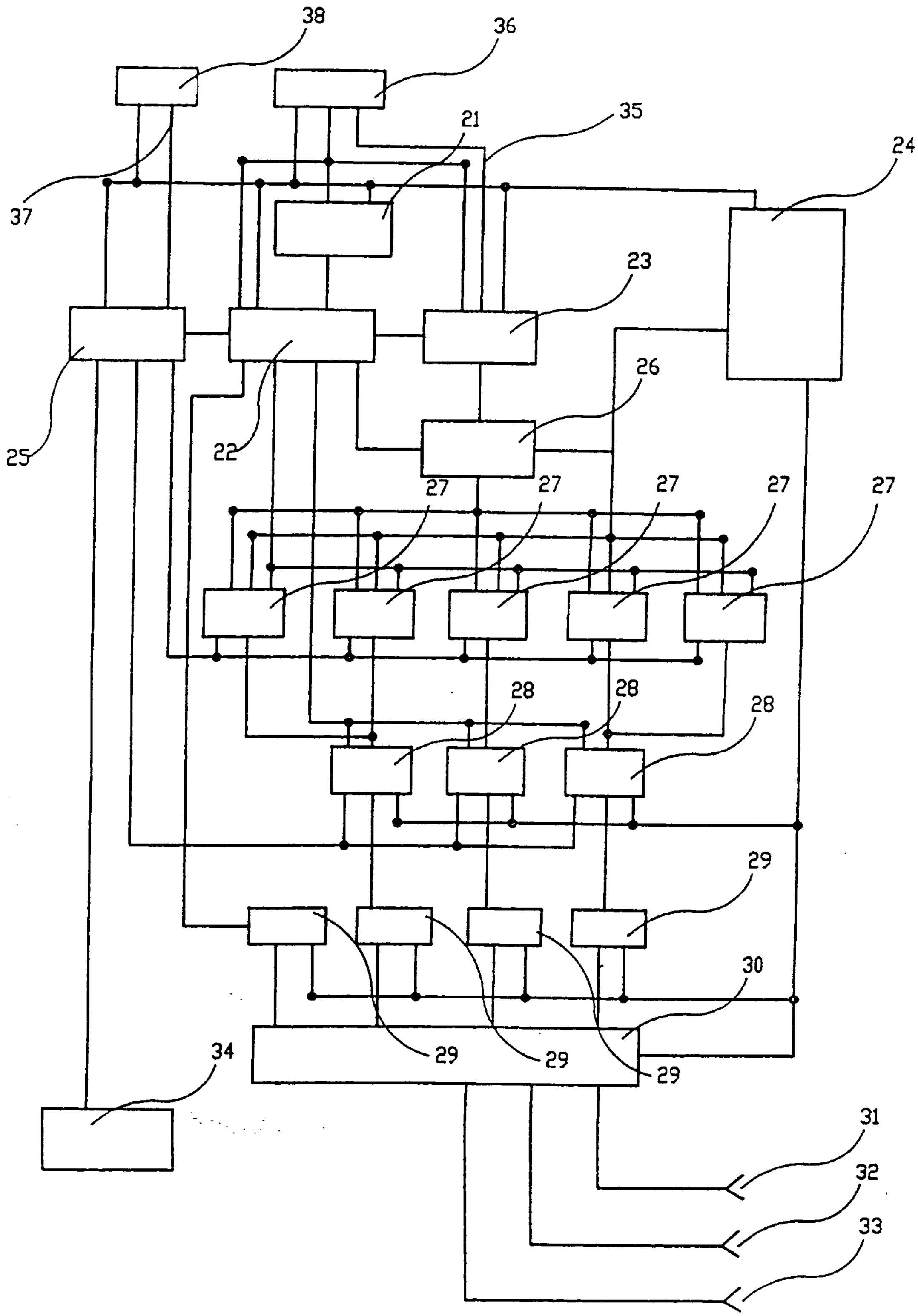
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Fig.2

INTERNATIONAL SEARCH REPORT

Inten. ...onal Application No
PCT/EP 95/03159

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04N1/48 A61B1/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US,A,5 264 925 (SHIPP) 23 November 1993 see column 1, line 8 - line 24 see column 2, line 59 - column 4, line 18 see column 4, line 33 - line 38	1,8
Y	see figure 1 ---	1-6,9
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[X] Further documents are listed in the continuation of box C. [X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
23 November 1995	08.12.95
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Thomas, R.M.

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